WOODS HOLE OCEANOGRAPHIC INSTITUTION

Woods Hole, Massachusetts

In citing this manuscript in a bibliography
the reference should be followed by the phrase:
UNPUBLISHED MANUSCRIPT.

Reference No. 56 - 52

MARINE METEOROLOGY

On the structure of trade-wind air below cloud

by

Joanne S. Malkus

Technical Report #40
Submitted to the Office of Naval Research
Under Contract Nonr 1721(00)(NR-082-021)

August 1956

APPROVED FOR DISTRIBUTION _______________ Director

On the structure of trade-wind air below cloud

Joanne S. Malkus

Abstract

The moisture and temperature structure of the trade-wind mixed layer are compared under conditions of strong versus weak trade. The data used are two series of aircraft psychrograph soundings made over the ocean near Puerto Rico in early spring. The first in conditions of strong undisturbed trade and high zonal index (April 10 - 28, 1946) and the second under conditions of weak rather disturbed trade and low zonal index (March 18 - April 7, 1953).

The weak trade soundings show a less homogeneous moisture distribution and a less stable temperature lapse rate. Considerable variation in structure of the lowest air accompanies changes in the trade regime which may give rise to significant fluctuations in energy input at the source region for atmospheric circulations. The importance of wind stirring in the upward transfer of moisture is indicated, which may affect the formation of trade cumulus clouds. Further studies investigating the relation between air and ocean structure at their boundary are suggested by the evidence herein, which may relate to the formation of tropical storms.

I. INTRODUCTION

In April 1946 the Wyman-Woodcock expedition to the Caribbean carried out 25 vertical airplane psychrograph soundings in order to study the structure of trade-wind air in the lowest 3 km over the sea. These records were analyzed in detail and reported on by Bunker, Haurwitz, Malkus, and Stommel (1949). These data were obtained during a period of relatively undisturbed strong trade with well developed low-level convection. During March-April 1953, another series of 9 soundings were obtained in the same region on an expedition made by the Woods Hole Meteorology group in collaboration with the Department of Meteorology, Imperial College, London. In contrast to the 1946 period, the latter soundings were obtained during relatively weak, disturbed trade and, during much of the time, poorly developed low-level convection.

A comparison of the structure and transports in the lower air between the two periods is now being undertaken. The first part of the results is presented here, namely a study of the moisture and temperature distribution below cloud base, and how it differed in the two cases. This work has been undertaken for primarily two reasons: the first to attempt to discover why convection was less well developed in the 1953 period and what part, if any, changed conditions below cloud may have contributed; and second, to compare the air structure and transports in the low levels under two different trade regimes in relation to fluctuations in the energy supply for larger scale phenomena such as tropical storms and the general circulation as a whole. The latter point requires some preliminary elucidation.

Riehl (1954) has suggested as a possible source of fluctuations in the hemispheric zonal index, variations in the trade-wind cell which is a main link in carrying the energy from the supply region to higher latitudes. The first step in the transport from the source, namely the lowest air over the tropical oceans, exerts an immediate and important control upon the amount, form, and distribution of the energy supplied. Previous studies of the trade-wind subcloud region have shown it to be about 600 m in depth (with extreme ranges from 300 - 1000 m), the lower four-fifths consisting of a well-mixed layer, generally topped by a slightly more stable stratum just below cloud base. The present investigation concerns the mixed portion only. Since this layer is in nearly marginal static stability with only a slight upward decrease of mixing ratio, very small changes indeed in outgo of heat and moisture from its top or in income from the bottom may alter the fluxes by an order of magnitude or even change their direction.

Riehl has further suggested a possible delicate balance between evaporation, windspeed, and sea surface roughness. He cites evidence that the evaporation rate may double discontinuously when the wind speed rises above the critical value for whitecaps, namely 6 - 7 m/sec, which is very near the average speed of the trade winds.

This would lead to considerable fluctuation in the energy input, since about 75% of it initially occurs in the form of latent heat. Fortunately the 1946 and 1953 observations fall on clearly different sides of the critical wind speed and the results may be examined with this suggestion in mind. This is done in Section IV after a brief comparison of the overall synoptic picture in the two cases and a discussion of the method of observation.

II. THE SYNOPTIC SITUATION IN THE WESTERN ATLANTIC TRADE DURING THE 1946 AND 1953 OBSERVING PERIODS

The period of April 10 - 28, 1946, was one of relatively strong undisturbed trade. The average (shipboard) wind speed on all observing days was 9.1 m/sec and the sea was generally rough with whitecaps present. The trajectories of the air reaching the observing region (50 - 100 miles north of San Juan, Puerto Rico) were from north of east. The subtropical high pressure cell was well developed, elongated from east to west, and had a central pressure departing little from 1023 mb. Rather little flow across it occurred during the period. The time cross section for all observing days and a typical surface map are shown in Figures 1a and 2a.

The period of March 18 - April 7, 1953 was one of weaker, more disturbed trade regime. The surface winds in the observing area averaged 5.7 m/sec and no whitecaps were seen on seven of the nine days. The time cross section is shown in Figure 1B and a typical surface map in Figure 2B. They show that travelling disturbances were more intense at all levels than in the same period of 1946. Middle and high cloudiness are frequent in the 1953 time section, while none are reported on that of 1946. Relatively lower zonal index during the 1953 observations is suggested by Figures 1 and 2 and further by Figure 3. The latter is a plot of the central pressure of the subtropical high cell, which averaged less than 1017 mb on all observing days and decreased markedly from the beginning to the end of the period. Not only did the zonal (easterly) wind component fall off, but it is likely that the meridional trade-wind cell was concomitantly running down. The equatorward component of flow disappears and actually reverses between March 30 and April 5, and the trajectories of the air reaching San Juan are from south of east.

It may thus be considered that the 1946 soundings show air structure typical of strong circulation (for the location and season) and the 1953 soundings show the features of weak circulation at the same place and season. They will therefore be designated as series H and L respectively throughout the rest of this report.

III. METHOD OF OBTAINING THE DATA USED

In each case the soundings were taken by a revised version of the M. I. T. psychrograph mounted on a PBY aircraft. Dry and wet-bulb temperatures were recorded as the aircraft spiralled upward at about 200 ft/min, a slow enough rate of climb for lag-free readings to be obtained. The spirals were about two miles in diameter and in series L they were frequently made around smoke flares which had been dropped to determine the surface wind direction. Additional wind information was obtained from the Imperial College meteorology group which made double theodolite pilot balloon observations from Anegada island (18°50'N, 64°20'W) which is 120 miles east-northeast of San Juan and generally within 20 miles of the observing area. The 1946 (series H) spirals were in the vicinity of a surface vessel which supplied the wind information.

For series L a wide-angle time lapse motion picture camera was used from the nose of the aircraft during all soundings. This made it possible to determine the location of the spirals relative to cloud groups and to assess the state of the sea surface. For series H this was done from the aircraft and ship observers' notes.

The accuracy of the observations and their method of reduction has been described in detail in the paper by Bunker et al (loc. cit., 1949) in which the series H soundings are published. The series L soundings appear at the back of this report, where temperature, mixing ratio, virtual and potential temperature are tabulated as functions of (true) altitude and pressure.

IV. INFORMATION GAINED FROM THE SOUNDINGS AND COMPARISON BETWEEN THEM

In series H, the temperature lapse rate in the mixed layer was always slightly subadiabatic and its mixing ratio hovered about a constant value, dropping only about 0.4 gm/kgm from the bottom of the layer to the top. Three questions were raised by these data: First, concerning the magnitude and direction of the sensible heat flux, which according to classical turbulence ideas should have been downward. Recently the existence of counter-gradient heat flows has been hypothesized and confirmed observationally (Bunker, 1956). Although the sensible heat accumulation by the lower trade is only about 25% that of the latent, the heating has been shown (Riehl and Malkus, 1956) to be vital in the maintenance of the circulation. Thus the direction and size of its flux in the lowest layers remains an important unresolved question. The second question concerned the origin of trade cumulus clouds. The subadiabatic lapse rate precluded their origin in Bénard-type convection cells, while roots in cloud-scale thermals were eliminated by horizontal runs determining drafts, virtual temperature, and turbulence below cloud base. A clue to the mechanism of origin of cloud groups was provided by the 1946 (series H) data where the lifting condensation level of the air in the mixed region was calculated and compared with the thickness of the layer. In cloudy areas, the top of the mixed layer reached nearly to the condensation level, while in clear zones away from clouds it fell considerably short of that height. Some recent airborne sea surface temperature measurements (Malkus, 1956) have suggested that warmer spots in the sea surface may give rise to weak convergences in the wind field sufficient to account for local thickening of the mixed layer of this magnitude and scale. Finally, a question concerning the mechanism of maintenance of convective-turbulence in the mixed layer itself was raised, and the relative roles of buoyancy and wind stirring therein. The vertical transports in the lower trades are undoubtedly a combination of turbulent shear flow and thermal turbulence in a fluid heated from below. The relative importance of these and the effect of their interaction has not been assessed.

The series L soundings have been analyzed and compared with those of series H with these questions in mind. Although it is not yet possible to give definite answers to any of them, nor to make an experiment isolating a single factor alone, such as wind strength or sea surface roughness, the differences in subcloud air structure in the two periods suggest that important fluctuations in energy input and transfer accompany changes in flow regime in this critical source region. The nature and magnitude of these differences give some clues as to their origin and possible effects upon other parts of the trade-wind atmosphere.

A summary of the major features of the mixed layer for series L is presented in Table 1. A comparison of the H and L series appears in Table 2, subdivided into clear and cloudy area soundings. The last five columns (right) of Table 1 were obtained by calculations from the soundings as follows: Plots of temperature, virtual temperature, and mixing ratio against height were made and the lapse rate of each determined graphically and checked by the method of least squares. The height, h, of the mixed layer was determined, as by Bunker et al. for series H, by picking the height at which the mixing ratio lapse rate increased suddenly. This level was usually well defined and was further confirmed in most cases by a concomitant stabilization of temperature lapse rate. The lifting condensation level was found from a tephigram, using the mean properties of the mixed layer air.

The lapse rate of virtual temperature averaged 4% greater than the temperature lapse rate for series L, but in no case went over to superadiabatic when the temperature lapse rate was sub-adiabatic. In contrast to series H, however, one case of super-adiabatic mixed layer was found in series L, namely that of the sounding of April 2. This was a day of particularly light wind, and the nose camera film showed the calmest sea of the period.

A rough calculation sheds light on the role of buoyancy. In the case of the average lapse rate of virtual temperature, T*, it may be shown that buoyant bubbles leaving the sea surface with virtual temperature excesses of 0.6 - 0.8°C could rise through about half the depth of the mixed layer before losing their buoyancy at normal rates of mixing. When the lapse rate is 5% superadiabatic, as in the case of April 2, they could rise through its entire depth before losing all buoyancy.

Prior to comparison of the two series using Table 2, it should be pointed out that of the 25 series H soundings, 16 were made in clear areas and 9 in cloudy, and generally one or more both clear and cloudy area soundings were made on a single observing day. Furthermore, wind and synoptic conditions varied little through the H period so that Table 2 essentially presents for series H a comparison between clear and cloudy area soundings at a single time. The temperature difference in the last column therefore probably means that at 11 m the temperature was slightly warmer in cloudy zones than in clear zones. In series L soundings were made in cloudy areas whenever any such were easily accessible to the aircraft. The five soundings entitled "clear area" were made on days when oceanic cloud groups were small and far between or absent altogether.* Thus in series L we are comparing "good trade cumulus days" versus "few or no trade cumulus days". Except for the very last day, namely April 7, the good trade cumulus days were confined to the beginning of the period, and in all cases confined to days when the flow was

*On April 1 enormous cumulonimbus buildups were visible about 70 miles north of the observing area. The ordinary trade cumulus groups were, however, rather widely spaced and not well developed.

from east or north of east. The days of poor convection (except for the somewhat anomalous case of April 1) were those in which the flow was from a direction well to south of east. This is reflected in the last two columns of Table 2, showing a wind averaging 57° more southerly and an 11-m air temperature 1.1°C warmer on poor days for convection.

The most significant difference between the H and L sub-cloud air lies in the moisture distribution. The air is wetter at the surface and drier at the top in series L and the mixing ratio lapse rate exceeds that of H by an average factor of 3.5! The character of the vertical moisture structure was quite different in the two series and was even recognizable on the plots of mixing ratio against height. A typical example from each series is reproduced in Figure 4. It appears that in the L series the water vapor just was not getting pumped up through the subcloud layer and it therefore accumulated in the lowest levels. This may, in turn, have inhibited further evaporation. From the effect of the higher relative humidity alone, the evaporation in series L would have only been 80% of that of series H, and if Riehl's suggestion is correct it may actually have been less than 50%. A possible important oceanographic consequence of such a "stopping down" of evaporation is discussed in the concluding paragraphs.

That turbulence in the subcloud layer was subnormal in series L has been suggested by Bunker (1955) from his low values of shearing stress, turbulent velocities, and eddy viscosities. What proportion of this subnormality of turbulence is attributable to reduced wind stirring and what proportion to diminished heating from below as a result of the changed air trajectories cannot be assessed from these data. The importance of wind stirring in regulating the features of low-level trade wind air is suggested, however, by two further calculations. The first is presented in the third column from the left in Table 2 which gives the difference in height between the lifting condensation level, LCL, and the top of the mixed layer, H, broken down again into clear and cloudy area categories. In the series H cloudy areas the top of the mixed layer averaged 87 m below the height of the LCL. In series L, this difference was only 14 m. The buoyancy available to bubbles was nearly the same in both cases and, if anything, greater in L. It seems likely, therefore, that the greater stirring produced by the wind was responsible in H for subcloud eddies being carried 87 m above the top of the mixed layer to reach saturation. In L the cloudy region LCL and the top of the mixed layer are, within observational error, equal so that no overshooting is indicated.

Finally, Table 1 shows that during the L period large variations in wind speed and mixed layer lapse rate occurred and an inverse relation between these variables is indicated. A correlation between wind speed and temperature lapse rate was computed and came out -0.68 even when corrected for the small number of observations. Despite the doubtful representativeness of island winds, this result is extremely suggestive that the upward transports of heat and moisture are greatly dependent upon wind stirring and may become considerably deranged after prolonged periods of subnormal winds. The reality of this inverse relation between subcloud stability and wind speed is further argued by examination of the average structure of the low-level Pacific trade (Riehl et al., 1951). As the current flows southwestward and accelerates, the subcloud lapse rate goes over gradually from slightly superadiabatic at latitude 32° to subadiabatic by latitude 21°, despite constant or even increased heating from below. The average windspeed increases by about 0.8 m/sec and the positive windshear doubles during that travel. Further tests of this relation will be possible in the Atlantic trade following the establishment of a surface vessel making wind and temperature soundings on a routine basis.

V. CONCLUDING REMARKS

Riehl's suggestion that important fluctuations in the atmospheric energy supply accompany changes in trade regime has received observational support at the first step, namely that from the ocean surface to the lowest air and upward through the first few hundred meters. The importance of wind stirring and/or sea surface roughness is indicated. One reason why the period of March 30 - April 7, 1953 was poor for convection in the observing area has been found: namely on "poor cloud days" the mixed layer top fell short of the condensation level by more than 200 m. Oceanic warm spots at least 0.4°C in amplitude would be required to thicken the layer by that amount (Malkus, 1956) and so far ones that pronounced have rarely been observed in the open sea. To find out why the few clouds that did form during that period were poorly developed we plan a further comparison of the upper levels of the series L and H soundings.

Changes such as described here in the low-level trade wind air from periods of high to low index may have important oceanographic consequences which may, in turn, play a role in controlling the formation of tropical storms. For example, if over a given source region evaporation is cut by a factor of two for a period of 90 days the sea surface will be about 1.2°C warmer than under normal evaporation, even if the heat loss is distributed through an ocean layer 100 m deep. This temperature rise would be doubled if the decreased wind stirring permitted the oceanic mixed layer to shrink to half that depth. A 2°C temperature difference in the sea surface may be critical in the formation and development of a hurricane.

Two types of study are suggested by this reasoning, which at present is little beyond the speculation stage:

First, a synoptic study comparing the number and intensity of storms forming in a given source region to the strength of the trades an appropriate distance up-current for the preceding 3 months and a comparison of the total number and intensity of hurricanes in a given season in the Atlantic or Pacific trade with the overall strength of that trade throughout the preceding spring.

Second, a combined oceanographic and meteorological observation program relating the character of the mixed layers of ocean and atmosphere, their interaction ahd how it affects and is affected by larger scale processes. Such a program is planned by this Institution utilizing the Research Vessel CRAWFORD together with the aircraft.

Acknowledgments: The writer wishes to acknowledge the enormous contribution by her colleague, Mr. Andrew Bunker, whose studies of the trade-wind mixed layer have set the precedent for this work and which promise in the future to resolve many of the questions left open at the present time.

Table I. Summary of Features of Mixed Layer for 1953 (series L) Soundings.

Date	Time	Location	Local Wind Direction	Anegada Wind		Sea	h	Lapse rate of temp. T	Lapse rate of virt. temp. T*	Lapse rate of mixing ratio w	LCL
	LST		° from N	°	m/sec	.	m	°C/100 m	°C/100 m	x $10^9 cm^{-1}$	m
March 18	1450	Cloudy area.	23	18	4	Calm. No whitecaps.	686	.94	.98	29	500
March 21	1400	Cloudy area.	83	93	5	Small waves. No whitecaps.	450	.93	M	M	500
March 25	1115	Cloudy area.	90	89	10	Large waves. Rough white-caps every-where.	550	.82	.90	28	655
March 30	1112	Clear area near edge of cloudy area. High cirrus pres.	Estimated 110	110	5	Medium waves. Some white-caps.	382	.95	.97	28	450
April 1	1045	Clear area near cloudy. Some cirrus Cunimb buildups 70 mi. north.	130	146	4	Small waves. No whitecaps.	382	.95	.98	7.4	580
April 2	1445	Clear area north of small cloudy area. Some cirrus.	118(smoke)	120	4	Sea calm. No whitecaps.	570	1.04	1.05	11	760
April 4	1150	Clear area. No clouds except over islands.	140(smoke)	140	6	Small waves. No whitecaps.	700	.90	.93	13	850
April 5	1300	Clear area. No cu except over islands. Middle clouds 8/10.	130(smoke)	140	7.5	Medium-small waves. No whitecaps.	446	.67	.76	32	855
April 7	0950	Cloudy area.	88(smoke)	96	5.5	Small waves. No whitecaps.	666	.91	.98	15	760
Average			101	105	5.7		537	.90	.94	20.4	653

Table 2. Comparison between 1946 (H) and 1953 (L) Mixed Layers

	h	LCL - h	Relative humidity (bottom)	Relative humidity (top)	Mixing ratio (bottom)	Mixing ratio (top)	Lapse rate of mixing ratio	Lapse rate of temperature	Wind speed		T_{11m}
	m	m	%	%	gm/kgm	gm/kgm	x 10^9 cm^{-1}	°C/100m	°	m/sec	°C
April 10-28 1946(H)											
clear	549	186	71	89	15.0	14.6	- 6.4	.90	87	8.9	25.7
cloudy	620	87	71	91	15.1	14.8	- 4.9	.85	96	9.5	25.8
average	575	150	71	90	15.05	14.7	- 5.8	.88	90	9.1	25.7
March 18 - April 7 1953(L)											
clear	496	204	76	85	15.3	14.4	-18.3	.90	131	5.3	25.6
cloudy	588	14	81	94	15.6	14.2	-24	.90	74	6.1	24.5
average	537	120	78	89	15.44	14.3	-20.4	.90	106	5.7	25.1

References

Bunker, A. F., B. Haurwitz, J. S. Malkus and H. Stommel, 1949: Vertical distribution of temperature and humidity over the Caribbean Sea. Pap. Phys. Ocean. Meteor. Mass. Inst. Tech. and Woods Hole Ocean. Inst., 11, No. 1, 82 pp.

Bunker, A. F., 1955: Turbulence and shearing stresses measured over the North Atlantic Ocean by an airplane-acceleration technique. J. Met., 12, 445 - 455.

Bunker, A. F., 1956: Measurements of countergradient heat flows in the atmosphere. Australian J. of Phys., 9, 133 - 143.

Malkus, Joanne S., 1956: Trade cumulus cloud groups: Some observations suggesting a mechanism of their origin. Unpublished manuscript submitted to Tellus.

Riehl, H., 1954: Variations of energy exchange between sea and air in the trades. Weather, 9, 335 - 340.

Riehl, H., T. C. Yeh, J. S. Malkus and N. E. LaSeur, 1951: The northeast trade of the Pacific Ocean. Q. J. Roy. Met. Soc., 77, 598 - 626.

Riehl, H., and J. S. Malkus, 1956: On the heat balance and maintenance of circulation in the trades. Tech. Rep't. submitted to the Office of Naval Research under Contract N6ori-02036 with the Univ. of Chicago and Contract No. Nonr 1721(00) with the Woods Hole Ocean. Inst. 14 pp.

Titles for Figures

Fig. 1. Time cross sections for the two observing periods April 10 - 28, 1946 (H), Fig. 1a, and March 18 - April 7, 1953 (L), Fig. 1b covering observation days only. Upper winds are RAWINS. A short barb indicates a speed of 5 mph, a long barb 10 mph. Surface winds are in Beaufort scale. The hatched region is the moist layer, the top of which is represented by a dotted line. The base of the westerlies is indicated by a dashed line. The greater strength of disturbances in the 1953 (L) period is suggested by more cloudiness and in particular more middle and upper clouds.

Fig. 2. Typical surface charts for the two observing periods. In each case the heavy solid line denotes a polar trough. Figure 2a is the chart for April 12, 1946, 1230 GCT chosen as typical of period H and Figure 26 is the chart for March 29, 1953, 1830 GCT chosen as typical of period L. Note the weaker subtropical high cell and relative north-south elongation of pressure systems on the latter.

Fig. 3. Plot of the central pressure of the subtropical high cell during the 1953 (L) observing period as a function of time. Taken from the 1830 GCT surface chart daily.

Fig. 4. Typical plots of mixing ratio against height for sounding series H (left-hand curve) and L (right-hand curve). The

curve for series H was plotted from the April 10 (1524 LST) 1946 sounding and the curve for series L was plotted from the April 2, 1953, sounding. Both soundings were made in the clear and show nearly equal depth of the mixed layer (solid horizontal line). The average moisture lapse rate in the L case is 2.5 times that of the H case and its fluctuations about the average are much less.

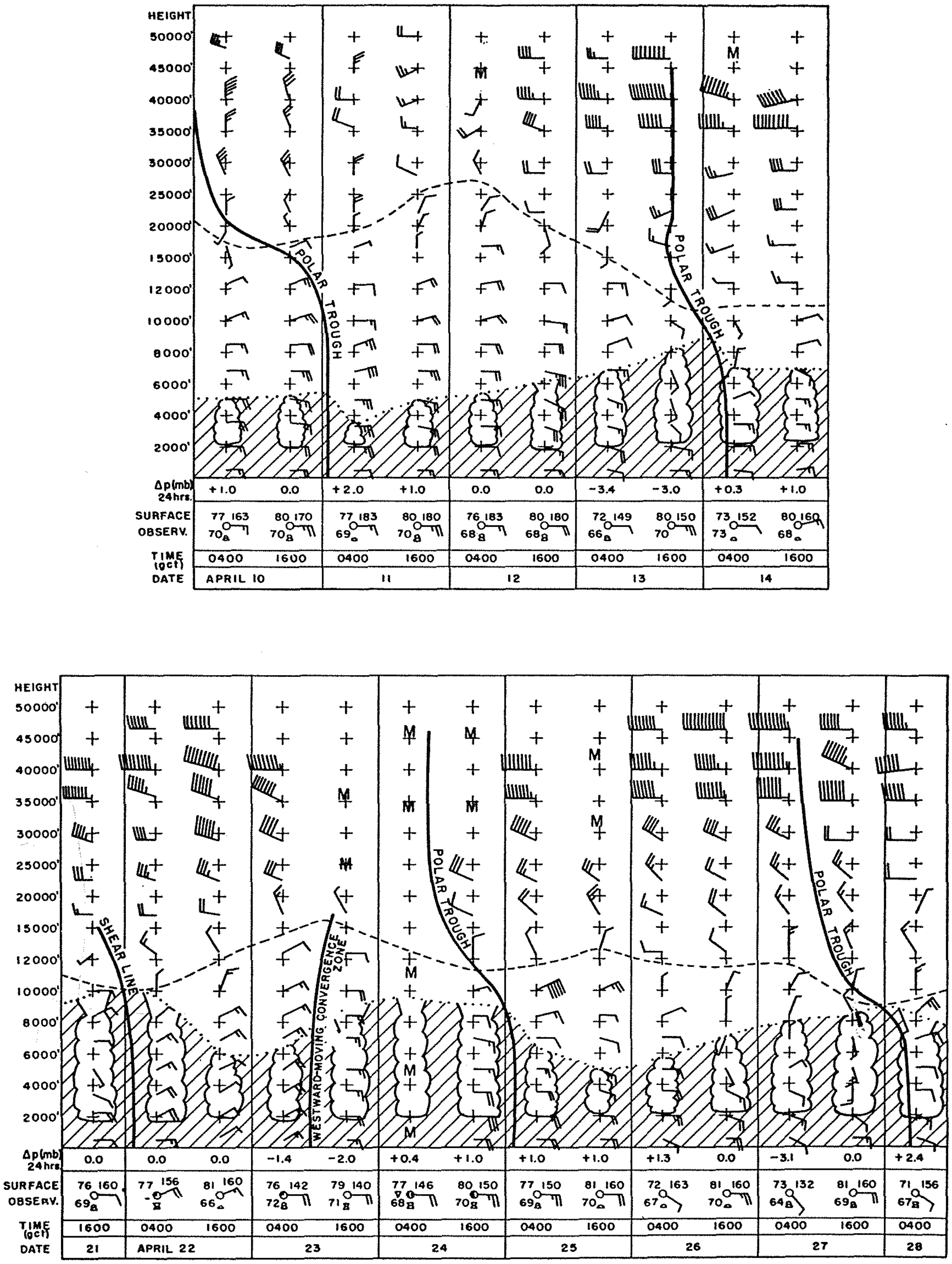

HEIGHT
50000'
45000'
40000'
35000'
30000'
25000'
20000'
15000'
12000'
10000'
8000'
6000'
4000'
2000'
POLAR TROUGH
SHEAR LINE
WESTWARD-MOVING CONVERGENCE ZONE
Δp(mb) 24hrs.
SURFACE OBSERV.
TIME (gct)
DATE
APRIL 10
11
12
13
14
21
APRIL 22
23
24
25
26
27
28

FIG. 1A

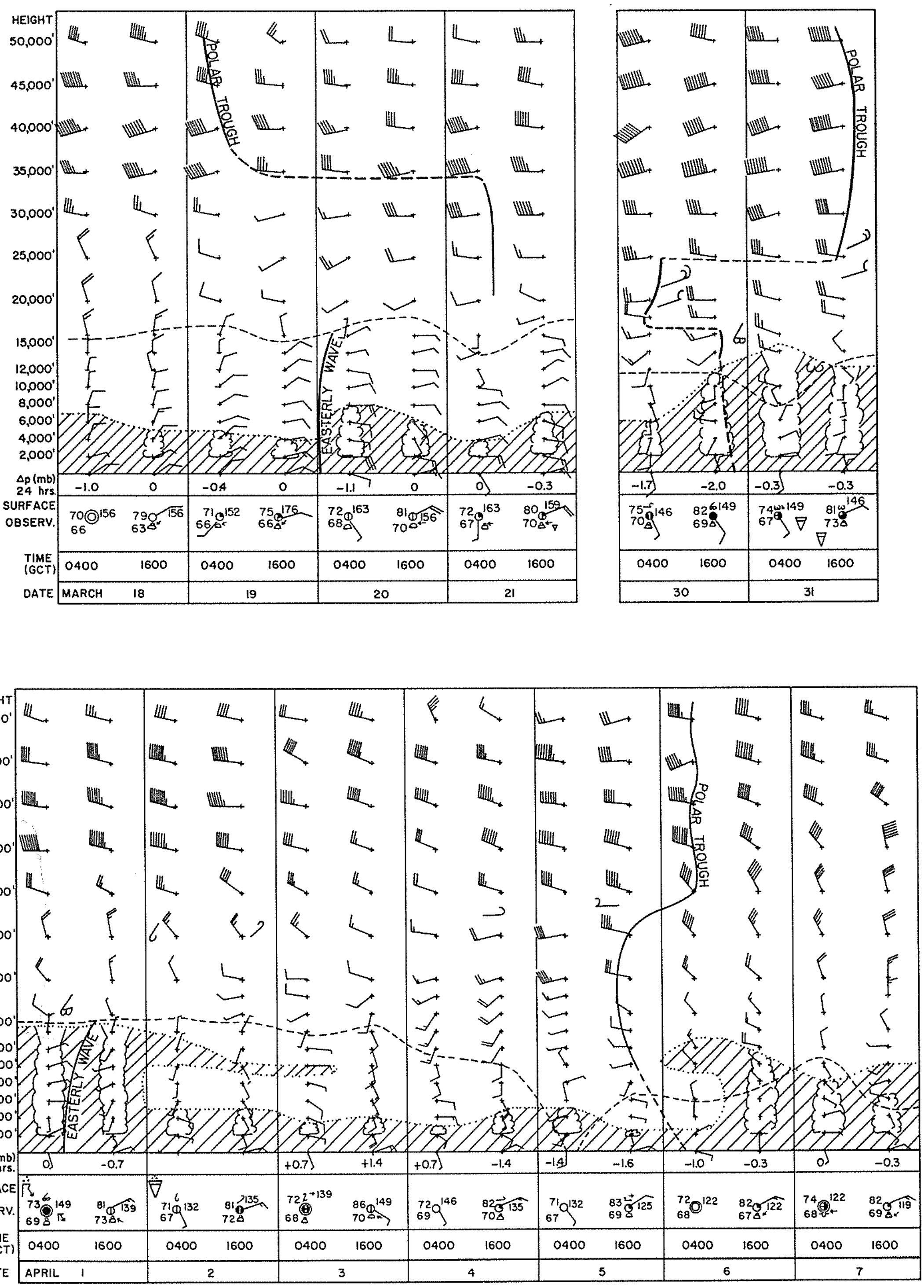

HEIGHT
50,000'
45,000'
40,000'
35,000'
30,000'
25,000'
20,000'
15,000'
12,000'
10,000'
8,000'
6,000'
4,000'
2,000'
POLAR TROUGH
EASTERLY WAVE
Δp (mb) 24 hrs.
SURFACE OBSERV.
TIME (GCT)
0400
1600
DATE
MARCH
18
19
20
21
30
31
APRIL
1
2
3
4
5
6
7

FIG. 1B

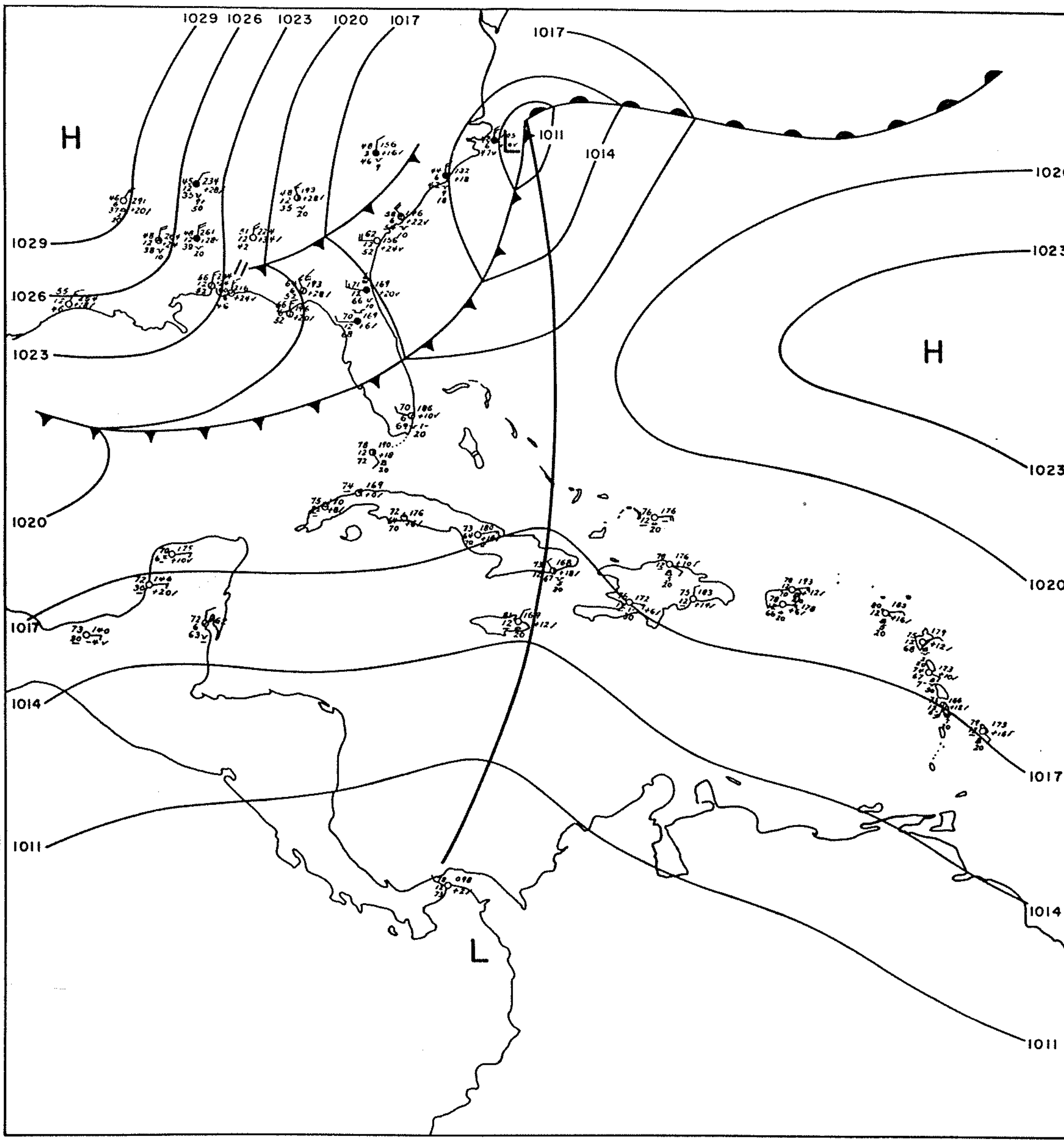
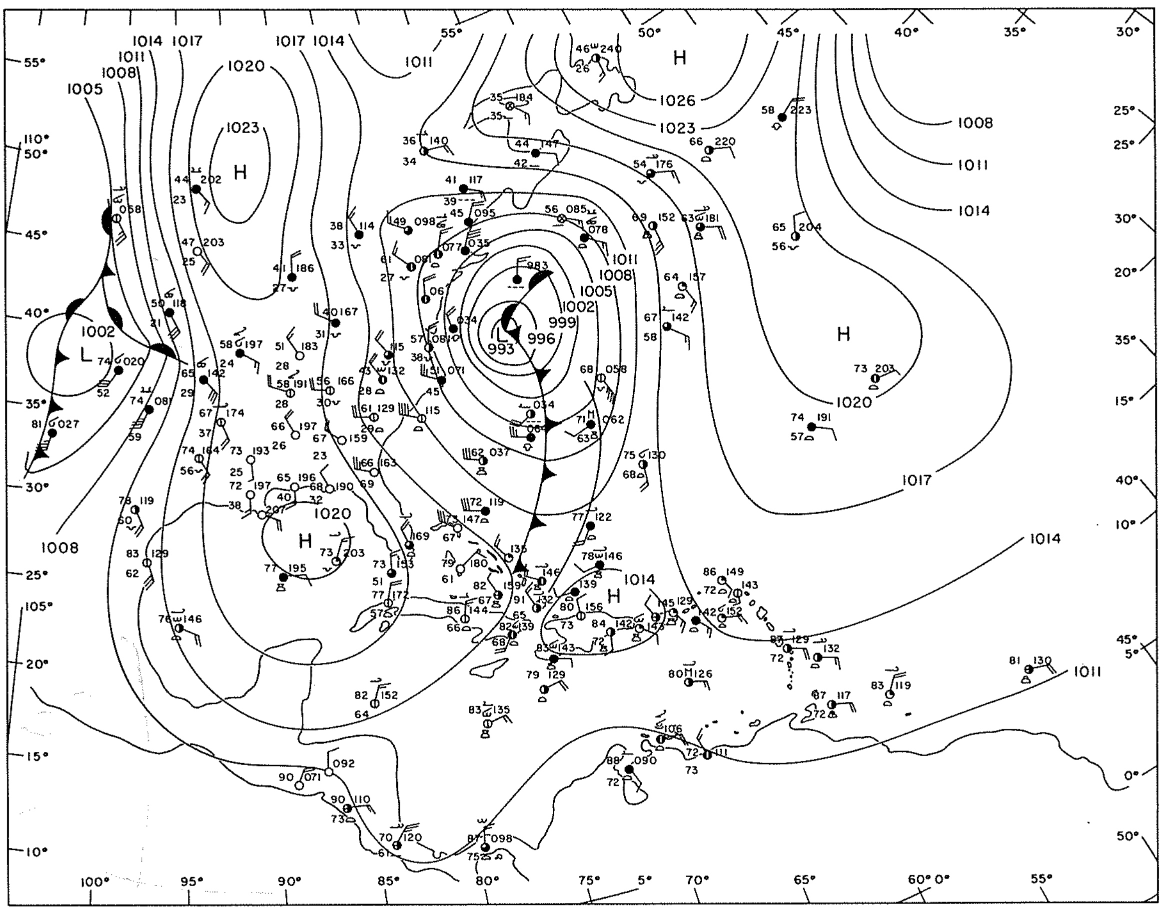


FIG. 2A



1014 1017
1011
1008
1005
1020
1023
H
1017 1014
1011
1026
1023
1008
1011
1014
H
1002
L
1011
1008
1005
1002
999
996
993
1020
1017
1014
1020
H
1014
H
1011
1008
55°
50°
45°
40°
35°
30°
25°
20°
15°
10°
110°
105°
100°
95°
90°
85°
80°
75°
70°
65°
60°
55°
0°
5°

FIG. 2B

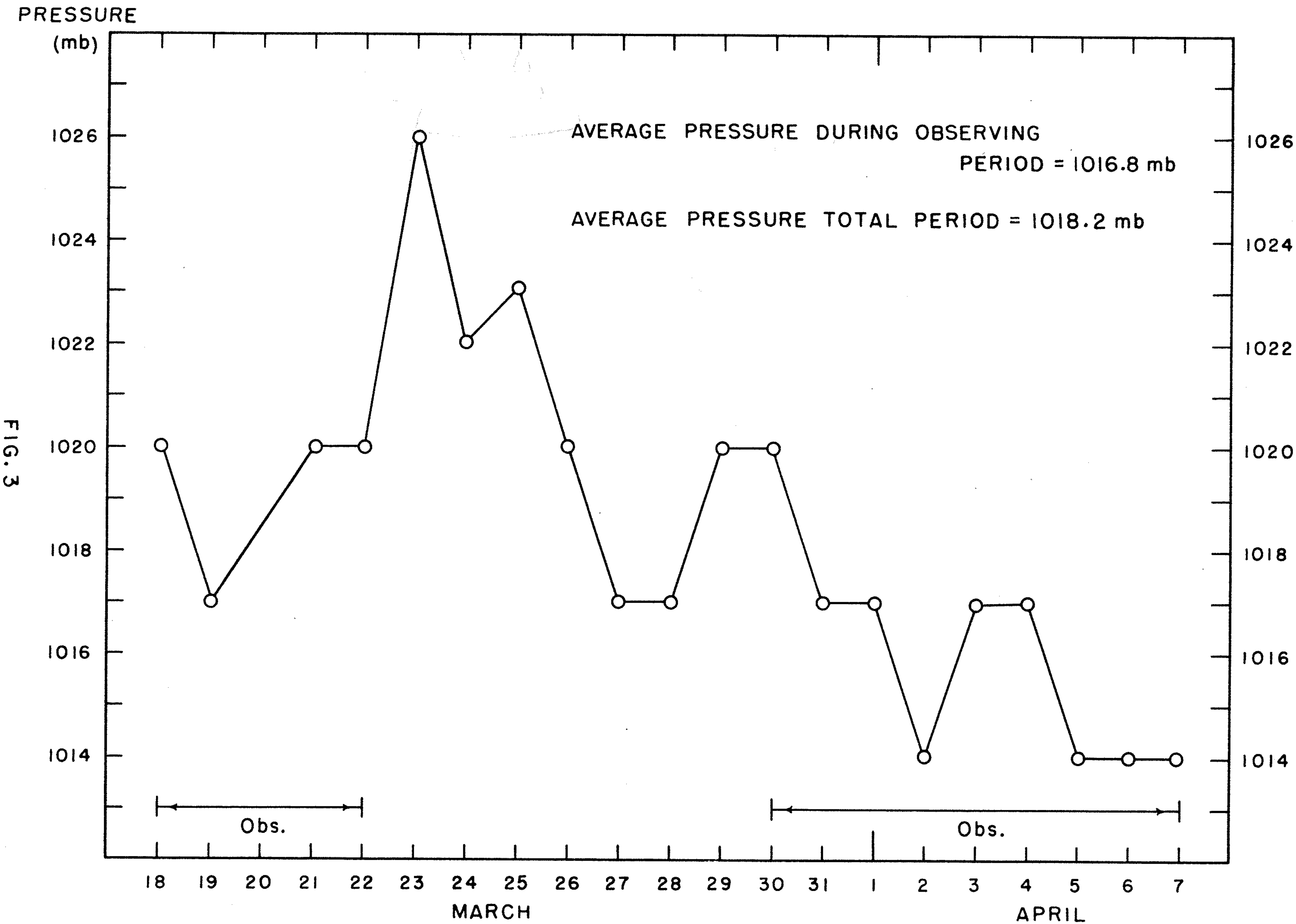

PRESSURE
(mb)
1026
1024
1022
1020
1018
1016
1014
AVERAGE PRESSURE DURING OBSERVING
PERIOD = 1016.8 mb
AVERAGE PRESSURE TOTAL PERIOD = 1018.2 mb
Obs.
Obs.
18
19
20
21
22
23
24
25
26
27
28
29
30
31
1
2
3
4
5
6
7
MARCH
APRIL

FIG. 3

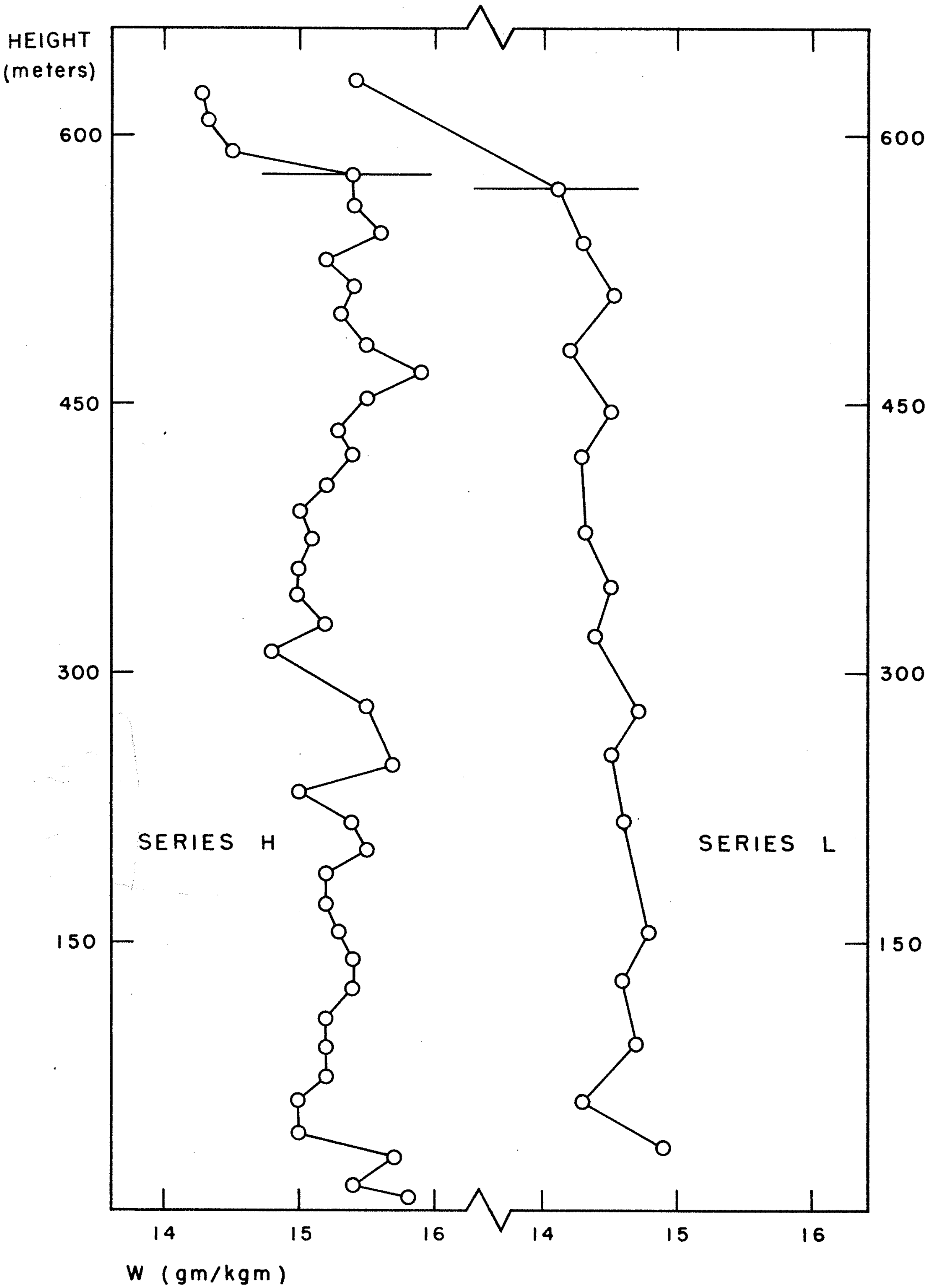

HEIGHT
(meters)
600
450
300
150
600
450
300
150
SERIES H
SERIES L
14
15
16
14
15
16
W (gm/kgm)

FIG. 4

1953 Soundings - Reduced and Tabulated

Temperature, T (°C), mixing ratio, w (gm/kgm), virtual temperature T* (°A) and potential temperature θ (°A) are presented in the following tables as functions of pressure p (mb) and height (true) h (m) for each of the nine 1953 soundings.

The times and locations of the soundings, the Anegada surface winds and the ambient cloud character are given in the heading to each.

March 18, 1953. 1450 LST. Sounding in cloudy area.

Wind 18°, 4 m/sec. Location: 5 miles north of Anegada.

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
1013.4	15	23.0	15.9	299.0	294.7
1007.9	55	23.1	15.5	299.1	295.4
1004.2	85	22.7	15.2	298.6	295.3
1000.4	115	22.3	14.9	298.1	295.3
996.9	145	21.9	14.8	297.7	295.2
993.4	177	21.7	14.8	297.5	295.3
989.7	209	21.3	14.8	297.1	295.2
986.1	241	21.0	14.6	296.8	295.1
982.7	273	20.6	14.5	296.4	295.0
979.0	305	20.2	14.7	296.0	294.9
975.5	336	20.0	14.6	295.8	295.0
971.9	367	19.7	14.5	295.4	295.0
968.4	398	19.4	14.2	295.1	295.0
964.9	429	19.1	14.1	294.8	295.0
961.4	460	18.9	14.0	294.6	295.1
957.9	492	18.6	14.1	293.3	295.1
954.4	524	18.4	13.8	293.0	295.1
950.9	556	18.1	13.8	292.7	295.1
947.4	588	17.8	13.6	293.4	295.1
943.9	620	17.5	13.6	293.1	295.1
940.5	652	17.1	13.4	292.6	295.1
937.0	683	17.0	13.4	292.5	295.3
933.6	714	17.0	12.6	292.4	295.4
930.1	745	16.5	12.5	291.9	295.4
923.3	810	16.3	12.5	291.5	295.6
919.9	840	16.3	12.2	291.4	295.9
916.6	870	15.5	12.4	290.9	295.6
913.1	900	15.8	12.5	291.2	296.4
909.8	930	15.4	11.9	290.7	296.2
906.5	960	15.0	11.7	290.2	296.1
903.1	992	14.6	11.4	289.8	296.0
899.8	1024	14.6	11.5	289.8	296.4
896.5	1056	14.2	11.3	289.4	296.2
893.1	1088	14.2	10.6	289.2	296.6
889.7	1120	14.5	9.9	289.4	297.4
886.5	1151	14.0	10.6	289.0	297.1
883.3	1182	13.8	10.7	288.8	297.3
880.0	1213	13.6	10.6	288.6	297.4
876.9	1244	13.4	10.4	288.4	297.5
873.5	1275	13.3	10.5	288.3	297.8
870.2	1306	13.0	10.5	288.0	297.7
867.0	1337	12.9	10.4	287.9	298.1

March 18, 1953. 1450 LST (contd.)

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
863.7	1368	12.6	10.2	287.6	298.1
860.5	1399	12.5	10.2	287.5	298.3
857.4	1430	12.3	9.8	287.2	298.4
854.1	1460	12.1	9.5	286.9	298.5
850.9	1485	11.9	9.7	286.8	298.6
847.8	1511	11.7	9.6	286.5	298.8
844.5	1537	11.7	9.4	286.5	299.1
841.2	1563	11.8	8.5	286.5	299.6
838.3	1589	11.7	9.0	286.4	299.7
835.1	1615	11.0	9.6	285.8	299.4
832.0	1645	11.3	8.5	286.0	300.0
828.9	1675	11.7	8.0	286.3	300.6
825.8	1715	11.3	8.0	285.9	300.6
822.7	1745	11.3	8.0	285.9	300.9
813.5	1835	10.8	8.0	285.2	301.2
810.4	1865	10.9	6.0	285.1	301.5
807.3	1895	11.1	5.0	285.2	302.1
798.2	2005	11.3	4.0	285.2	303.3

March 21, 1953. 1400 LST. Sounding in cloudy area.

Wind 93°, 5 m/sec. Location: 25 miles north of Anegada.

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
1015.8	20	25.8	M	M	297.4
1013.9	35	25.6	M	M	297.4
1010.3	70	25.4	M	M	297.5
1006.6	100	25.1	M	M	297.5
1002.9	135	24.7	M	M	297.5
999.3	166	24.6	M	M	297.7
995.8	197	23.9	M	M	297.3
991.1	228	23.8	M	M	297.6
988.5	259	23.4	16.8	299.6	297.4
985.0	290	23.2	16.8	299.4	297.5
981.4	322	23.1	16.1	299.2	297.7
974.3	386	22.6	17.1	298.9	297.8
970.8	417	22.2	17.0	298.5	297.7
967.3	448	22.1	17.0	298.4	298.0
963.8	480	21.9	16.4	298.1	298.0
960.3	510	21.9	16.8	298.1	298.4
956.8	540	22.0	16.4	298.2	298.9
954.3	570	21.3	16.1	297.3	298.4
949.8	600	21.2	16.3	297.3	298.7
946.3	630	20.8	15.8	296.8	298.7
942.9	660	20.7	15.8	296.7	299.0
936.0	720	18.4	10.9	293.5	297.1
929.1	780	18.4	9.3	293.3	297.9
925.7	808	18.4	9.4	293.3	298.2
922.3	836	18.1	9.5	293.0	298.3
919.0	864	17.8	9.7	292.7	298.2
915.5	892	17.4	10.2	292.4	298.0
912.2	920	17.2	10.2	292.2	298.2
905.5	976	16.7	10.4	291.7	298.3
902.2	1004	16.6	10.1	291.6	298.5
898.9	1032	16.4	9.7	291.3	298.7
895.5	1060	16.1	9.6	291.0	298.6
892.1	1095	15.6	10.8	290.7	298.5
888.9	1130	15.2	11.1	290.4	298.4
885.7	1165	15.1	11.0	290.2	298.6
882.4	1200	15.1	11.0	290.2	299.0
879.3	1235	14.9	11.0	290.0	299.0
872.6	1305	14.6	10.4	289.6	299.4
869.4	1340	14.5	9.9	289.4	299.6
866.1	1375	14.5	9.1	289.3	299.8
862.9	1410	14.5	8.9	289.3	300.0
859.8	1444	14.1	9.7	289.0	300.0
856.5	1478	13.8	9.5	288.7	300.0
853.3	1512	13.9	8.2	288.5	300.5
850.2	1556	14.0	7.1	288.5	300.8
846.9	1580	13.9	7.3	288.4	301.2
840.7	1642	13.8	6.2	288.1	301.6
837.5	1673	13.6	5.5	287.8	301.7

March 21, 1953. 1400 LST. (contd.)

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
834.4	1704	13.5	5.2	287.6	302.0
831.3	1735	13.4	5.2	287.5	302.3
828.2	1766	13.1	5.8	287.3	302.3
825.1	1797	12.6	6.7	287.0	302.0
822.0	1828	12.7	5.7	286.9	302.5
818.9	1859	12.4	6.3	286.7	302.5
815.9	1890	12.0	7.1	286.4	302.5

March 25, 1953. 1115 LST. Sounding in cloudy area.

Wind 89°, 10 m/sec. Location: 2 miles north of Anegada.

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
1016.5	15	23.0	13.7	298.6	294.6
1014.6	31	22.5	13.9	298.2	294.4
1011.0	61	22.3	14.0	298.0	294.4
1007.3	92	21.9	13.5	297.5	294.3
1003.6	122	21.6	13.4	297.2	294.3
1000.0	153	21.4	13.3	297.0	294.4
996.5	183	21.2	13.3	296.8	294.5
992.8	214	20.8	13.1	296.4	294.4
989.2	244	20.4	13.0	295.9	294.3
985.7	275	20.3	12.8	295.8	294.5
982.1	305	20.2	13.0	295.7	294.6
978.6	336	19.8	12.7	295.3	294.6
975.0	366	19.6	12.6	295.0	294.7
971.5	397	19.4	12.6	294.8	294.7
968.0	427	19.0	12.6	294.4	294.6
964.5	458	19.0	12.3	294.4	294.9
961.0	488	18.6	12.4	294.0	294.8
957.5	519	18.3	12.6	293.7	294.8
954.0	549	18.2	12.6	293.6	295.0
950.5	580	18.0	12.1	293.4	295.0
947.0	610	17.7	11.8	293.0	295.0
943.4	641	17.5	11.6	292.8	295.2
936.7	702	17.1	11.4	292.3	295.4
933.2	732	17.0	11.0	292.2	295.6
929.8	763	16.7	11.2	291.9	295.6
926.4	793	16.3	11.5	291.5	295.5
923.0	824	16.0	11.4	291.2	295.5
919.7	854	15.9	11.3	291.1	295.7
916.2	885	15.7	11.0	290.9	295.7
912.9	915	15.6	11.0	290.7	296.1
909.6	946	15.5	10.9	290.6	296.5
906.2	976	15.3	10.8	290.4	296.8
902.9	1007	15.2	10.6	290.3	296.7
899.6	1037	14.9	10.8	290.0	296.6
847.6	1525	12.5	9.3	287.3	299.6
844.3	1556	12.2	8.9	286.9	299.6
841.4	1586	12.1	9.0	286.9	299.8
838.2	1617	11.9	9.2	286.7	299.9
835.1	1647	11.7	8.8	286.4	300.0
832.0	1678	11.7	8.3	286.3	300.3
828.9	1708	11.4	8.9	286.1	300.3
826.0	1739	11.0	8.8	285.7	300.4
822.7	1769	11.6	8.1	286.2	301.2

March 25, 1953. 1115 LST. (contd.)

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
819.6	1800	11.1	7.8	285.7	301.0
816.6	1830	11.0	7.6	285.5	301.1
810.4	1891	10.8	7.4	285.3	301.4
807.4	1922	10.6	7.3	285.1	301.6
804.3	1952	10.6	7.3	282.5	301.9
801.3	1983	10.6	7.3	282.5	302.3
798.3	2013	10.8	7.4	282.7	302.7
795.3	2044	10.6	7.6	282.5	302.9
792.2	2074	10.0	7.8	281.9	302.6
789.3	2105	10.3	4.9	282.6	303.4
787.8	2120	10.4	5.3	282.7	303.6
786.3	2135	10.3	5.5	282.5	303.6
783.6	2166	10.0	5.4	282.3	303.6
782.1	2181	9.9	6.1	282.0	303.6
780.7	2196	9.7	6.3	281.8	303.6

March 30, 1953. 1112 LST. Sounding in clear area near edge of cloudy area. High cirrus present. Wind 110°, 5 m/sec. Location: 12 miles east-southeast of Anegada.

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
1012.9	34	25.2	16.6	301.4	297.1
1009.3	66	24.9	16.8	301.2	297.4
1005.6	96	24.4	17.0	300.7	297.0
1001.9	129	24.2	16.7	300.4	297.1
998.3	160	24.0	16.6	300.2	297.4
994.8	192	23.6	16.8	299.8	297.2
991.1	224	23.2	16.5	299.4	297.0
987.5	256	23.0	16.4	299.2	297.2
984.0	288	22.8	16.0	298.9	297.3
980.4	320	22.5	16.1	298.6	297.4
976.7	351	22.3	15.9	298.4	297.4
973.3	382	21.9	16.0	298.0	297.3
969.8	413	21.7	15.5	297.7	297.4
966.3	444	21.5	15.1	297.4	297.4
962.8	475	21.2	15.1	297.1	297.4
955.8	540	20.7	15.0	296.6	297.5
952.3	570	20.4	14.2	296.2	297.4
948.8	600	20.1	14.4	295.9	297.4
945.3	633	20.0	14.2	295.7	297.6
941.9	666	19.8	13.9	295.5	297.8
938.4	699	19.6	14.0	295.3	298.0
935.0	732	19.3	13.4	294.9	298.0
931.5	765	19.2	13.4	294.8	298.2
928.1	795	19.2	13.1	294.8	298.5
924.7	825	19.2	12.6	294.6	298.9
921.3	857	18.9	12.5	294.3	299.0
914.5	920	18.5	12.3	293.9	299.3
911.2	950	18.5	12.3	293.9	299.6
907.9	980	18.1	12.4	293.5	299.5
904.5	1010	17.8	12.5	293.2	299.5
901.2	1040	17.5	12.2	292.9	299.5
897.9	1072	17.3	12.3	292.7	299.5
894.5	1104	17.1	12.4	292.5	299.6
891.1	1136	17.0	12.2	292.4	300.1
887.9	1168	16.9	11.6	292.2	300.1
884.7	1200	16.7	11.5	291.9	300.3
881.4	1232	16.1	11.4	291.3	300.1
878.3	1260	16.1	11.5	291.3	300.4
871.6	1325	15.8	11.6	291.0	300.7
868.4	1355	15.3	11.8	290.6	300.5
865.1	1386	15.0	11.5	290.2	300.5
861.9	1417	15.0	11.4	290.2	300.8
858.8	1448	14.8	11.5	290.0	300.9
855.5	1479	14.6	11.4	289.8	301.0
852.3	1510	14.6	11.1	289.8	301.4
845.9	1561	14.4	10.8	289.5	301.7

April 1, 1953. 1045 LST. Sounding in clear area near cloudy area. Some cirrus present. Wind 146°, 4 m/sec. Location: 10 miles east of Anegada.

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
1014.8	15	24.9	15.6	300.9	296.7
1012.9	30	24.6	15.4	300.6	296.6
1009.3	65	25.0	15.3	300.9	297.4
1005.6	97	24.3	15.4	300.3	297.0
1001.9	128	24.1	15.2	300.0	297.1
998.3	160	23.7	15.3	299.6	297.2
994.8	192	23.5	15.4	299.4	297.0
991.1	224	23.2	15.5	299.1	297.1
987.5	256	22.9	15.0	298.8	297.1
984.0	288	22.7	15.5	298.6	297.4
980.4	320	22.2	15.1	298.1	297.0
976.9	350	21.9	14.2	297.6	297.0
973.3	382	21.6	14.3	297.3	297.0
962.8	475	20.6	13.0	296.1	296.8
959.3	506	20.4	12.7	295.8	296.9
955.8	537	20.2	12.7	295.6	297.0
952.3	568	20.2	12.6	295.6	297.4
948.8	599	19.7	12.7	295.1	297.0
945.3	630	19.5	12.5	294.9	297.1
938.4	695	19.1	12.7	294.5	297.4
935.0	726	18.5	12.5	293.9	297.2
931.5	757	18.6	11.9	293.9	297.6
928.1	788	18.5	11.9	293.8	297.9
924.7	819	18.4	12.1	293.7	298.1
921.3	850	18.0	12.1	293.3	298.1
918.0	880	17.8	12.1	293.1	298.2
914.5	913	17.8	11.5	293.0	298.5
911.2	944	17.9	11.1	293.1	299.1
904.5	1004	17.4	10.9	292.5	299.2
901.2	1034	17.2	10.8	292.3	299.3
897.9	1064	17.1	10.6	292.1	299.4
894.5	1095	16.6	10.7	291.6	299.2
878.3	1255	16.0	8.4	290.7	300.2
874.9	1287	15.8	8.4	290.5	300.4
871.6	1319	15.7	8.5	290.4	300.6
868.4	1351	15.2	8.4	289.5	300.4
865.1	1383	15.1	7.9	289.7	300.6
861.9	1415	15.0	7.7	289.5	300.8
858.8	1444	15.0	7.5	289.5	301.1
855.5	1473	14.9	6.9	289.3	301.3
852.3	1500	14.7	6.8	289.1	301.5
849.2	1525	14.6	6.5	288.9	301.5
845.9	1550	14.6	6.3	288.9	302.0

April 2, 1953. 1445 LST. Sounding in clear area north of small cloudy area. Some cirrus present. Wind 120°, 4 m/sec.

Location: 5 miles east of Anegada.

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
1011.2	35	25.3	14.9	301.2	297.4
1007.6	62	25.2	14.3	301.0	297.6
1003.9	95	24.9	14.7	300.8	297.7
1000.2	130	24.4	14.6	300.2	297.4
996.6	155	24.3	14.8	300.1	297.6
989.4	218	23.5	14.6	299.3	297.4
985.8	254	23.1	14.5	298.9	297.4
982.3	290	22.9	14.7	298.7	297.4
978.7	320	22.4	14.4	298.2	297.2
975.2	350	22.1	14.5	297.9	297.1
971.6	380	21.6	14.3	297.4	296.9
968.1	418	21.4	14.3	297.2	296.9
964.6	445	21.1	14.5	296.9	296.9
961.1	480	20.9	14.2	296.6	297.1
957.6	507	20.5	14.5	296.3	296.9
954.1	544	20.4	14.3	296.2	297.1
950.6	570	20.0	14.1	295.7	297.0
943.6	632	19.9	12.6	295.3	297.6
940.2	668	19.9	11.4	295.1	298.0
936.7	700	19.8	11.0	295.0	298.3
933.3	735	19.6	10.9	294.7	298.4
929.8	760	19.3	10.7	294.4	298.5
926.4	795	19.0	10.8	294.1	298.5
923.0	825	18.9	10.2	293.9	298.7
919.6	855	18.9	9.6	293.8	299.1
916.3	890	18.9	9.4	293.8	299.4
912.8	915	18.8	9.3	293.7	299.6
909.5	955	18.8	9.4	293.7	299.9
906.2	985	18.3	9.6	293.2	299.7
902.8	1015	18.2	9.2	293.0	299.9
899.5	1042	17.9	9.9	292.8	299.9
896.2	1075	17.9	9.2	292.7	300.2
892.8	1105	17.6	9.2	292.4	300.3
889.4	1140	17.3	9.2	292.1	300.3
886.2	1170	17.2	9.1	292.0	300.5
883.0	1200	17.0	9.4	291.9	300.6
879.7	1230	16.7	9.5	291.6	300.7
876.6	1260	16.4	9.5	291.3	300.6
873.2	1295	16.3	9.7	291.2	300.9
869.9	1325	16.2	9.4	290.9	300.9
866.7	1355	15.6	9.3	290.4	300.8
863.4	1390	15.5	8.8	290.2	301.1
860.2	1420	15.1	8.8	289.8	301.0
857.1	1456	15.1	7.5	289.6	301.3
853.8	1485	15.2	7.3	289.7	301.7
850.6	1520	15.2	8.3	289.9	302.0

April 2, 1953. 1445 LST. (contd.)

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
847.5	1553	14.9	8.6	289.6	302.0
844.2	1588	14.5	9.0	289.3	301.9
838.0	1650	14.2	9.3	289.0	302.2
834.8	1680	14.6	5.2	288.7	303.0
831.7	1713	14.7	4.9	288.8	303.5
828.6	1745	14.5	4.5	288.5	303.6
825.5	1780	14.2	3.9	288.1	303.6
822.4	1810	14.0	3.7	287.9	303.7
819.3	1840	13.8	3.6	287.6	303.8
813.2	1900	12.7	7.6	287.2	303.3
840.9	1622	14.1	9.8	289.0	301.9
838.0	1650	14.1	9.6	289.0	302.2
834.8	1680	14.2	8.9	289.0	302.6
831.7	1713	14.0	8.6	288.7	302.7
828.6	1745	13.8	8.4	288.5	302.8
825.5	1780	13.6	8.3	288.2	303.0
822.4	1810	13.5	7.8	288.1	303.2
818.3	1840	13.5	6.6	287.8	303.5
816.2	1870	13.5	6.0	287.7	303.7
813.2	1900	13.0	7.2	287.5	303.6
807.0	1968	12.7	7.4	287.4	303.9
804.0	2000	11.8	7.5	286.3	303.3
800.9	2033	11.9	6.4	286.4	303.7
797.9	2065	11.6	6.7	286.0	303.7
794.9	2098	11.6	6.6	286.0	304.0
791.9	2130	11.5	5.6	285.7	304.3
788.8	2162	11.5	5.8	285.7	304.5
785.9	2194	11.2	5.6	285.4	304.5
782.9	2226	11.2	5.0	285.3	304.7
780.1	2258	11.0	4.4	285.0	304.9
777.3	2290	11.0	3.9	285.1	305.2
774.5	2318	10.7	4.0	284.6	305.3
771.6	2339	10.5	3.9	284.4	305.4
768.7	2360	10.3	4.3	284.3	305.5
765.7	2388	10.3	3.7	284.1	305.8
760.0	2437	9.7	3.5	283.5	305.7
754.0	2483	9.2	3.7	283.0	305.8

April 4, 1953. 1150 LST. Sounding in clear area. No clouds except over islands. Wind 140°, 6 m/sec. Location: 5 miles east of Anegada.

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
1014.4	23	26.2	15.0	302.1	298.0
1009.6	65	25.4	14.6	301.3	297.6
1005.9	100	25.0	14.4	300.8	297.6
1002.2	130	24.6	14.1	300.4	297.5
998.6	163	24.3	14.3	300.1	297.5
995.1	195	24.1	14.3	299.9	297.6
991.4	228	23.8	14.4	299.6	297.6
987.8	259	23.4	14.6	299.2	297.5
984.3	290	23.0	14.4	298.8	297.4
980.7	322	22.7	14.2	298.5	297.5
977.2	354	22.6	14.1	298.4	297.6
973.6	385	22.2	14.3	298.0	297.5
970.1	417	22.0	14.2	297.8	297.5
966.6	449	21.9	14.0	297.6	297.8
963.1	479	21.5	14.3	297.3	297.6
959.6	511	21.2	14.1	296.9	297.6
956.0	543	21.0	14.0	296.7	297.7
952.6	575	20.8	13.8	296.5	297.8
949.1	607	20.4	14.1	296.1	297.6
945.6	639	20.0	14.1	295.7	297.5
942.2	669	19.8	13.7	295.4	297.7
938.7	699	19.8	13.8	295.5	298.1
935.3	729	19.8	12.2	295.2	298.5
931.8	759	19.7	11.6	295.0	298.7
928.4	790	19.6	10.4	294.7	298.9
925.0	822	19.4	10.2	294.4	299.0
921.6	854	18.9	10.8	294.0	298.9
918.3	886	18.9	10.1	293.9	299.2
914.8	918	18.7	10.1	293.7	299.4
911.5	950	18.8	9.6	293.7	299.8
908.2	980	18.5	9.7	293.4	299.7
904.8	1014	18.2	9.6	293.1	299.8
898.2	1075	17.5	9.9	292.4	299.6
894.8	1107	17.4	9.9	292.3	299.9
891.4	1140	17.0	10.1	292.0	299.9
888.2	1170	16.8	9.9	291.7	299.9
885.0	1202	16.7	9.2	291.5	300.1
868.7	1360	15.2	9.1	290.0	300.2
865.4	1390	14.8	10.1	289.8	300.2
862.2	1423	14.6	10.2	289.6	300.2
859.1	1457	14.6	10.2	289.6	300.6
855.8	1490	14.6	8.1	289.2	301.0
852.6	1523	14.2	8.5	288.9	300.8
849.5	1556	14.1	8.3	288.8	301.4
846.2	1580	13.9	7.5	288.4	301.1
842.9	1615	13.9	7.3	288.4	301.4
840.0	1642	13.7	7.3	288.2	301.5
836.8	1674	13.6	7.3	288.1	301.8

April 4, 1953. 1150 LST. (contd.)

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
827.5	1767	13.3	6.7	287.7	302.6
824.4	1799	13.4	5.5	287.6	302.9
821.3	1830	13.6	5.3	287.7	303.4
818.2	1860	13.6	5.7	287.8	303.6
815.2	1890	13.6	5.8	287.8	304.0
813.6	1907	13.6	6.4	287.9	304.2
812.1	1920	13.8	5.7	288.0	304.5
809.0	1945	14.0	4.9	288.1	304.9
806.0	1972	13.9	4.7	287.9	305.1
802.9	1999	13.6	4.8	287.6	305.2
801.4	2009	13.7	5.0	287.8	305.5
799.9	2021	13.7	4.8	287.7	305.7
796.9	2047	13.7	4.4	287.7	306.0

April 5, 1953. 1300 LST. Sounding in clear area. No cumulus present except over islands. Middle clouds 8/10. Wind 140°, 7.5 m/sec.

Location: 10 miles east of Anegada.

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
999.8	130	23.8	14.6	299.6	296.9
996.2	160	23.4	14.3	299.2	296.6
992.7	190	23.4	13.4	299.0	297.0
989.0	225	23.3	13.2	298.9	297.3
985.4	257	23.1	13.6	298.8	297.5
981.9	290	22.8	13.7	298.5	297.5
978.3	320	22.4	13.4	298.0	297.3
964.2	446	21.7	12.9	297.2	297.8
960.7	476	21.6	11.7	296.9	298.1
953.7	540	21.1	11.8	296.4	298.2
950.2	570	20.6	11.8	295.9	297.8
946.7	600	20.5	11.9	295.8	298.0
943.2	630	19.9	12.6	295.3	297.7
936.3	695	19.7	11.8	295.0	298.3
932.9	730	19.5	11.7	294.8	298.4
929.4	765	19.3	11.7	294.6	298.6
926.0	795	19.0	11.8	294.3	298.6
919.2	855	18.6	12.0	293.9	298.8
915.9	885	18.4	11.9	293.7	299.0
909.1	950	17.8	11.8	293.1	299.0
905.8	980	17.6	11.7	292.9	299.2
902.4	1010	17.5	11.9	292.8	299.3
899.1	1040	17.1	11.6	292.4	299.2
895.8	1070	16.8	11.6	292.1	299.3
885.8	1170	16.1	11.3	291.3	299.6
879.3	1240	15.6	10.3	290.6	299.8
876.2	1270	15.3	10.5	290.3	300.0
872.8	1292	15.2	10.0	290.2	300.4
866.3	1356	14.4	9.6	289.3	299.7
863.0	1388	14.7	8.9	289.5	300.4
859.8	1430	14.7	7.7	289.2	300.7
853.4	1490	14.5	7.1	288.9	302.1
850.2	1520	14.6	6.5	288.9	301.4
847.1	1550	14.6	5.7	288.8	302.9
843.8	1580	14.5	5.6	288.7	302.1
837.6	1640	13.8	5.5	288.0	301.9
828.2	1740	13.9	5.1	288.0	303.0
825.1	1770	13.9	4.1	287.8	303.4
822.0	1800	13.9	3.8	287.8	303.7
818.9	1830	13.9	3.9	287.8	304.0
815.8	1860	13.8	3.8	287.7	304.2
812.8	1890	13.7	3.8	287.6	304.3
806.6	1950	13.1	4.3	287.1	304.3
803.6	1990	12.7	4.0	286.6	304.3
800.5	2020	12.7	3.9	286.6	304.6
797.5	2060	12.5	4.0	286.4	304.7

April 5, 1953. 1300 LST. (contd)

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
794.5	2092	12.2	3.9	286.1	304.7
791.5	2124	11.9	4.1	285.8	304.7
788.4	2156	11.7	4.2	285.6	304.8
785.5	2188	11.7	4.0	285.6	305.1
782.5	2220	11.3	3.9	285.2	305.0
776.9	2284	10.4	4.7	284.4	304.7
774.1	2316	10.0	5.3	284.1	305.4
768.3	2380	9.4	5.8	283.6	304.5
765.3	2410	8.9	5.8	283.1	304.3
759.6	2470	9.0	6.1	283.3	304.9
756.6	2500	9.4			305.7
753.6	2530	9.3			306.0
750.6	2565	9.6	9.5	284.4	305.7
744.9	2625	9.7	8.9	284.4	307.5
742.1	2660	9.5	9.0	284.2	307.5
736.5	2720	9.1	9.1	283.9	307.7
733.7	2748	9.0	9.2	283.8	308.0
730.9	2776	9.1	8.6	283.8	308.5
728.1	2804	9.3	8.4	284.0	309.0
722.6	2860	8.5	8.5	283.2	308.6
717.1	2940	8.7	5.6	282.9	309.8
714.4	2972	8.5	5.2	282.6	309.9
708.9	3036	8.3	4.7	282.3	310.5
706.2	3068	8.1	2.9	281.8	310.6
703.5	3100	8.0	2.5	281.6	310.9
700.8	3130	7.8	1.9	281.3	311.0
698.0	3162	7.7	1.1	281.1	
689.9	3230	7.1	1.1	280.5	
687.1	3252	6.8	1.2	280.2	

April 7, 1953. 0950 LST. Sounding in cloudy area. Wind 96°, 5.5 m/sec.

Location: 20 miles north of Anegada.

p (mb)	h (m)	T (°C)	w (gm/kgm)	T* (°A)	θ (°A)
1013.1	12	24.9	15.2	300.8	296.8
1011.2	28	24.7	14.6	300.5	296.7
1007.6	66	24.9	14.6	300.7	297.3
1003.9	95	24.1	14.6	299.9	296.7
1000.2	130	24.0	14.4	299.8	296.9
996.6	156	23.5	14.4	299.3	296.7
993.0	193	23.3	14.2	299.0	296.8
989.4	229	23.1	14.1	298.8	297.0
985.8	255	22.8	14.2	298.5	297.0
982.3	290	22.4	14.3	298.1	296.8
978.7	318	21.8	14.0	297.5	296.5
975.2	353	21.8	14.1	297.5	296.9
971.6	385	21.6	14.0	297.3	297.0
968.1	418	21.2	14.1	296.9	296.7
964.6	447	20.9	14.1	296.6	296.7
961.1	478	20.6	13.9	296.3	296.8
957.6	510	20.2	14.1	295.9	296.6
954.1	541	20.3	13.6	295.9	297.0
950.6	574	19.8	13.6	295.4	296.9
947.1	601	19.7	13.2	295.2	297.0
940.2	665	19.0	13.6	294.6	297.0
936.7	698	19.2	12.4	294.6	297.6
933.3	729	18.9	12.2	294.2	297.6
929.8	760	18.7	11.8	294.0	297.8
926.4	793	18.5	11.6	293.7	297.9
923.0	823	18.7	10.8	293.8	298.5
919.6	853	18.7	10.6	293.7	298.9
916.3	885	18.6	10.9	293.7	299.1
912.8	915	18.1	11.2	293.3	298.9
909.5	945	18.1	11.1	293.3	299.3
906.2	978	17.6	11.5	292.8	299.0
902.8	1010	17.7	10.9	292.8	299.5
899.5	1040	17.8	10.7	292.9	299.9
896.2	1071	17.2	10.4	292.2	299.6
892.8	1100	17.0	10.3	292.0	299.7
886.2	1170	16.9	9.4	291.7	300.3
879.7	1230	16.6	9.3	291.4	300.8
876.6	1262	16.2	9.3	291.0	300.5
873.2	1292	16.0	8.9	290.7	300.6
869.9	1323	15.9	8.9	290.6	300.9
866.7	1355	15.7	8.2	290.3	300.9
863.4	1387	15.6	8.3	290.3	301.2
860.2	1420	15.6	7.8	290.2	301.5
857.1	1453	15.3	7.4	289.8	301.5
853.8	1479	15.3	6.5	289.6	301.8
850.6	1505	15.3	5.4	289.4	302.1
847.5	1531	15.3	4.4	289.3	302.4
844.2	1560	14.9	4.2	288.8	302.4
840.9	1590	14.6	4.1	288.5	302.4
831.7	1666	14.5	6.6	288.8	303.3
828.6	1696	14.4	6.6	289.7	304.4

Technical Report Distribution List
ONR Project NR-082-021

24 August 1953

Addressee	Copies
Geophysics Branch, Code 416, Office of Naval Research, Washington 25, D. C.	2
Director, Naval Research Laboratory, Attention: Technical Information Officer, Washington 25, D. C.	6
Officer-in-Charge, Office of Naval Research, London Branch Office, Navy No. 100, Fleet Post Office, New York, New York	5
Office of Naval Research, Branch Office, 346 Broadway, New York 13, New York	1
Office of Naval Research, Branch Office, 150 Causeway Street, Boston, Massachusetts	1
Office of Naval Research, Branch Office, Tenth Floor, The John Crerar Library Building, 86 East Randolph Street, Chicago, Illinois	1
Office of Naval Research, Branch Office, 1030 East Green Street, Pasadena 1, California	1
Office of Naval Research, Branch Office, 1000 Geary Street, San Francisco, California	1
Office of Technical Services, Department of Commerce, Washington 25, D. C.	1
Armed Services Technical Information Center, Documents Service Center, Knott Building, Dayton 2, Ohio	5
Assistant Secretary of Defense for Research and Development, Attn: Committee on Geophysics and Geography, Pentagon Building, Washington 25, D. C.	1
Department of Aerology, U. S. Naval Post Graduate School, Monterey, California	1
Aerology Branch, Bureau of Aeronautics (Ma-5), Navy Department, Washington 25, D. C.	1
Mechanics Division, Naval Research Laboratory, Anacostia Station, Washington 20, D. C., Attention: J. E. Dinger, Code 7110	1
Radio Division I, Code 7150, Naval Research Laboratory, Anacostia Station, Washington 20, D. C.	1

Addressee	Copies
Meteorology Section, Navy Electronics Laboratory, San Diego 52, California, Attention: L. J. Anderson	1
Library, Naval Ordnance Laboratory, White Oak, Silver Spring 19, Maryland	1
Bureau of Ships, Navy Department, Washington 25, D. C., Attention: Code 851 (Special Devices Center)	1
Bureau of Ships, Navy Department, Washington 25, D. C., Attention: Code 327 (Technical Library)	2
Chief of Naval Operations, Navy Department, Washington 25, D. C., Attention: Op-533D	2
Oceanographic Division, U. S. Navy Hydrographic Office, Suitland, Maryland	1
Library, Naval Ordnance Test Station, Inyokern, China Lake, California	1
Project Arowa, U. S. Naval Air Station, Building R-48, Norfolk, Virginia	2
The Chief, Armed Forces Special Weapons Project, P. O. Box 2610, Washington, D. C.	1
Office of the Chief Signal Officer, Engineering and Technical Service, Washington 25, D. C., Attn: SIGGGM	1
Meteorological Branch, Evans Signal Laboratory, Belmar, New Jersey	1
Headquarters Quartermaster Research and Development Command, Quartermaster Research and Development Center, U. S. Army, Natick, Massachusetts. Attention: Environmental Protection Division	1
Office of the Chief, Chemical Corps, Research and Engineering Division, Research Branch, Army Chemical Center, Maryland	2
Commanding Officer, Air Force Cambridge Research Center, 230 Albany Street, Cambridge, Massachusetts, Attn: ERHS-1	1
Willow Run Research Center, University of Michigan, Willow Run Airport, Ypsilanti, Michigan, Attn: Shelia Coon, Librarian	1

Addressee	Copies
Headquarters, Air Weather Service, Andrews Air Force Base, Washington 20, D. C., Attention: Director Scientific Services	2
Commander, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, Attention: WCREO-2	1
Commanding General, Air Force Cambridge Research Center, 230 Albany Street, Cambridge, Massachusetts, Attention: CRHSL	1
Commanding General, Air Research and Development Command, P. O. Box 1395, Baltimore 3, Maryland	1
Department of Meteorology, Massachusetts Institute of Technology, Cambridge, Massachusetts, Attention: H. G. Houghton	1
Department of Meteorology, University of Chicago, Chicago 37, Illinois, Attention: H. R. Byers	1
Institute for Advanced Study, Princeton, New Jersey, Attention: J. von Neumann	1
Scripps Institution of Oceanography, La Jolla, California, Attention: R. Revelle	1
General Electric Research Laboratory, Schenectady, New York, Attention: I. Langmuir	1
St. Louis University, 3621 Olive Street, St. Louis 8, Missorui, Attention: J. B. Macelwane, S. J.	1
Department of Meteorology, University of California at Los Angeles, Los Angeles, California, Attention: M. Neiburger	1
Department of Engineering, University of California at Los Angeles, Los Angeles, California, Attention: L. M. K. Beolter	1
Department of Meteorology, Florida State University, Tallahassee, Florida, Attention: W. A. Baum	1
Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, Attention: C. Iselin	1

Addressee	Copies
The Johns Hopkins University, Department of Civil Engineering, Baltimore, Maryland, Attention: R. Long	1
The Johns Hopkins University, Department of Physics, Homewood Campus, Baltimore, Maryland, Attention: G. Plass	1
New Mexico Institute of Mining and Technology, Research and Development Division, Socorro, New Mexico, Attention: E. Workman	1
University of Chicago, Department of Meteorology, Chicago 37, Illinois, Attention: H. Riehl	1
Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, Attention: A. Woodcock	1
General Electric Research Laboratory, Schenectady, New York, Attention: V. Schaefer	1
Geophysical Institute, University of Alaska, College, Alaska, Attention: C. T. Elvey	1
Blue Hill Meteorological Observatory, Harvard University, Milton 86, Massachusetts, Attention: C. Brooks	1
Laboratory of Climatology, Johns Hopkins University, Seabrook, New Jersey	1
Department of Meteorology and Oceanography, New York University, New York 53, New York, Attention: B. Haurwitz	1
Texas A and M, Department of Oceanography, College Station, Texas, Attention: J. Freeman, Jr.	1
Director of Technical Services, Headquarters, Dugway Proving Grounds, Dugway, Utah	1
Rutgers University, College of Agriculture, Department of Meteorology, New Brunswick, New Jersey	1
National Advisory Committee of Aeronautics, 1500 New Hampshire Avenue, N.W., Washington 25, D. C.	2
Travelers Weather Research Center, 700 Main Street, Hartford 15, Connecticut	1

Addressee	Copies
U. S. Weather Bureau, 24th and M Streets, N. W., Washington 25, D. C., Attention: Scientific Services Division	2
Air Coordinating Committee, Subcommittee on Aviation Meteorology, Room 2D889-A, The Pentagon, Washington, D. C.	1
American Meteorological Society, 3 Joy Street, Boston 8, Massachusetts, Attention: The Executive Secretary	1
Research Professor of Aerological Engineering, College of Engineering, Department of Electrical Engineering, University of Florida, Gainesville, Florida	1
The Hydrographer, U. S. Navy Hydrographic Office, Washington 25, D. C.	8
Division of Oceanography, U. S. Navy Hydrographic Office Washington 25, D. C.	2

ADDITIONAL DISTRIBUTION LIST

Addressee	Copies
Brookhaven National Laboratory, Upton, L. I., New York, Attention: Meteorology Group	1
Chemical Corps, Biological Laboratories, Technical Library, Camp Detrick, Frederick, Maryland	2
Dr. August Raspet, Engineering and Industrial Research Station, Mississippi State College, State College, Mississippi	2
Dr. E. W. Hewson, Professor of Meteorology, Department of Civil Engineering, University of Michigan, Ann Arbor, Michigan	1
Dr. Hunter Rouse, Director, Iowa Institute of Hydraulic Research, State University of Iowa, Iowa City, Iowa	1
Head, Department of Physics, University of New Mexico, Albuquerque, New Mexico	1
Mr. Wendell A. Mordy, Hawaiian Pineapple Research Institute, Honolulu, Hawaii	1

Addressee	Copies
Dr. E. G. Bowen, Chief, Division of Radiophysics, Commonwealth Scientific Industrial Research Organization, University Grounds, Chippendale, N. S. W., Australia	1
Department of Statistics, Wharton School, University of Pennsylvania, Philadelphia 4, Pennsylvania	1
Pennsylvania State College, School of Mineral Industries, State College, Pennsylvania, Attention: H. Panosfky	1
University of Wisconsin, Department of Meteorology, Madison, Wisconsin, Attention: V. Suomi	1
Institute of Atmospheric Physics, University of Arizona, Tucson 25, Arizona, Attention: J. E. McDonald	1
Diffusion Project, Round Hill, South Dartmouth, Massachusetts	1
United States Department of Agriculture, Southern Forest Experiment Station, Federal Building, Asheville, North Carolina, Attention: G. M. Byram	1
Professor Max A. Woodbury, Logistics Research Project, 707 22nd Street, N.W., Washington, D. C.	1
Dr. Yale Mintz, Department of Meteorology, University of California, Los Angeles, California	1